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Short communication

Waterbird densities in South European rice fields as a function of rice management

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In recent years there has been great concern regarding agricultural land uses and their importance for the conservation of biodiversity (Pain & Pienkowski 1997). Rice *Oryza sativa* cultivations represent 15% of the world's wetlands today (Lawler 2001) and have been shown to be of great importance for aquatic birds in areas such as southern Europe (Fasola & Ruíz 1996), North America (Elphick 2000), Japan (Maeda 2001) and West Africa (Tréca 1994). For many species, rice fields have replaced the original wetland habitats lost to reclamation and drainage. Rice fields function as temporary wetlands, with conditions changing drastically in the course of the year. In southern Europe, paddies are flooded in spring to prepare for seed plantation, during summer, water levels are kept high, and in September/October the paddies are drained to facilitate the harvest. During winter the water level in the rice fields depends on rainfall and agricultural management.

Birds can enhance straw decomposition in flooded fields (Bird *et al*. 2000); flooding attracts birds to the rice fields and speeds straw losses while reducing weed biomass in the paddies (Manley *et al*. 2005). However, modernization of rice farming influences conditions for waterbirds. For example, better drainage systems can eliminate the wet winter conditions in rice fields that have proven important for aquatic birds (Elphick & Oring 2003), and changes in water levels and straw management can have an influence on the use of rice paddies by birds (Elphick & Oring 1998). In Portuguese rice fields, flooded fields seem to harbour the highest amounts of waste rice, an important food source for some birds (Lourenço & Piersma 2008). However, other studies have contradicted this finding, suggesting that flooding fields reduces the amount of waste rice due to seed decomposition and germination (Stafford *et al*. 2006).

To understand how rice field conditions influence the bird community during the winter, we analysed bird densities in the rice field areas around the Tejo and the Sado estuaries, Portugal, and related these to straw management and water level in the paddies.

METHODS

The lower basins of the Tejo and Sado rivers in central Portugal harbour large rice field plantations. Field work took place in 10 areas around the estuaries of these rivers (for more details, see Lourenço & Piersma 2008).

After the harvest, in September/October, stubble is left standing in the fields. During the following months, some farmers plough the fields, mixing the stubble with the soil; others leave it and later burn the stubble. The water level in the fields also differs between paddies due to both rainfall and drainage, with some fields completely drying out, others remaining moist, some with water in ditches, and others remaining flooded. Finally, some fields are set-aside to allow ground nutrient recovery.

When bird censuses were performed, every paddy was characterized according to the stage of straw management (mature rice, standing stubble, ploughed fields and set-aside fields) and presence of water (flooded fields, moist fields, dry fields) (Lourenço & Piersma 2008).

We randomly selected 120 rice paddies, representing over 10% of the total surface of the study areas (280 ha out of a total 2547 ha). Adjacent paddies were rejected to avoid the risk of double-counting birds flushed during the censuses. Bird censuses were performed every 2 weeks, from October 2005 through March 2006, and in December 2006 and January 2007, always avoiding hunting days because of disturbance. The total number of counts in individual fields was 885.

All non-passerine birds present within the fields were counted. Census data were first converted into densities and later analysed fitting generalized mixed-effects models for each species. We used the log link function and a quasi-Poisson error structure to account for overdispersion in the density data (Pinheiro & Bates 2000). For the models we used the amount of water in the field (dry, moist or flooded) and the stage of straw management (mature rice, standing stubble, ploughed field or set-aside) as fixed factors; estuary (Tejo or Sado), site (the 10 study areas) paddy and date were used as random factors, nesting paddy within site and site within estuary, while date was nested within this nesting structure. To account for the temporal

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Table 1. Species preferences for different water levels and straw management stages. All densities are in birds/10 ha ± se. In each line of the Table, different letters indicate significant differences in the *a posteriori* Tukey HSD tests.

	Water in the field		
	dry	moist	flooded
Little Egret	0.3 ± 0.1[a]	2.4 ± 0.3[b]	4.3 ± 0.6[b]
Grey Heron	0.3 ± 0.1[a]	1.1 ± 0.1[a]	1.9 ± 0.1[b]
White Stork	0.3 ± 0.1[a]	2.8 ± 0.4[a]	8.1 ± 0.9[b]
Greater Flamingo	0.0 ± 0[a]	0.0 ± 0[a]	11.4 ± 2.5[b]
Pied Avocet	0.0 ± 0[a]	0.0 ± 0[a]	19.3 ± 5.1[b]
Northern Lapwing	0.1 ± 0.0[a]	3.9 ± 1.5[a]	24.9 ± 4.1[b]
Black-tailed Godwit	0.0 ± 0[a]	0.0 ± 0[a]	85.8 ± 1.7[b]

	Straw management stage			
	mature rice	standing stubble	ploughed field	set-aside
Little Egret	0.0 ± 0[a]	2.8 ± 0.3[b]	1.3 ± 0.2[a]	0.0 ± 0[a]
Grey Heron	0.0 ± 0[a]	1.2 ± 0.3[b]	0.2 ± 0.1[a]	0.2 ± 0.1[a]
White Stork	0.0 ± 0[a]	1.6 ± 0.3[b]	0.2 ± 0.0[a]	1.2 ± 1.3[b]
Pied Avocet	0.0 ± 0[a]	0.0 ± 0[a]	15.7 ± 2.9[b]	0.0 ± 0[a]
Northern Lapwing	0.0 ± 0[a]	0.9 ± 0.3[a]	0.6 ± 0.2[a]	20.1 ± 8.1[b]
Black-tailed Godwit	0.0 ± 0[a]	0.9 ± 0.3[a]	66.6 ± 1.2[b]	0.0 ± 0[a]
Common Redshank	0.0 ± 0[a]	0.1 ± 0.0[a]	2.1 ± 0.4[b]	1.9 ± 0.2[b]

variation we used a type 1 autocorrelation structure (Box *et al*. 1994) for the last random factor, date.

The Akaike Information Criterion (AIC) was used to select the best model for each species through backwards stepwise selection. Finally, we used Tukey's HSD (honestly significant difference) tests to evaluate differences between treatments in the variables that were included in the final fitted models.

RESULTS

The most abundant species in the rice fields were waders, herons, egrets and storks. The densities were generally quite low, with a large proportion of counted fields being empty of birds. We detected a total of 39 non-passerine bird species, of which the 13 most common were used for further analysis.

For five species, Cattle Egret *Bubulcus ibis*, Black-winged Stilt *Himantopus himantopus*, Common Snipe *Gallinago gallinago*, Lesser Black-backed Gull *Larus fuscus* and Black-headed Gull *Larus ridibundus*, none of the fixed factors were included in the final fitted models. Straw management stage was included in the final fits for seven species – Little Egret *Egretta garzetta*, Grey Heron *Ardea cinerea*, White Stork *Ciconia ciconia*, Pied Avocet *Recurvirostra avosetta*, Northern Lapwing *Vanellus vanellus*, Black-tailed Godwit *Limosa limosa* and Common Redshank *Tringa totanus*. The amount of water in the paddies was also included in the final fitted models for seven species, including Greater Flamingo *Phoenicopterus roseus*, for which it was the only fixed variable included in the final model (Table 1).

All seven species affected by water level showed higher densities in flooded fields (Table 1). Only Little Egret had similar densities in flooded and moist fields, with no significant difference between the two (Tukey test: $P > 0.1$).

Of the seven species with straw management in the final model (Table 1), Little Egret, Grey Heron and White Stork showed higher densities in standing stubble fields, although the last had similar densities in set-aside fields (Tukey test: $P > 0.1$). Pied Avocet, Black-tailed Godwit and Common Redshank had higher densities in ploughed fields, but in the last case there was no significant difference between the density in ploughed and set-aside fields (Tukey test: $P > 0.05$). Northern Lapwing was the only species with the highest densities in set-aside fields.

DISCUSSION

The observed densities in our study areas (4.07 ± 0.13 birds/ha) are comparable to waterbird densities in nearby estuarine areas (4.72 birds/ha in Granadeiro *et al*. 2007). The result is consistent with the notion that rice fields are currently a very important habitat for aquatic birds (e.g. Fasola & Ruíz 1996, Elphick 2000). It is also likely that the poor state of natural wetlands in many parts of the world contributes to the high use of rice fields, and that their current importance results from a lack of natural alternatives

(Lawler 2001). In fact, in areas where good quality natural wetlands are still abundant, bird densities in local rice fields are much lower than in natural areas (Tourenq *et al.* 2001).

Still, as rice plantations represent 15% of the world's wetlands and in many places are the only lasting habitats for aquatic birds (Elphick 2000), correct management of these agricultural habitats becomes imperative for the conservation of waterbirds. What advice on proper management can this study give? Most study species were significantly affected by at least one of the tested variables. The few species whose densities were unaffected by these variables were generalists like Cattle Egret and the two species of gulls (Moreira 1995a, Tourenq *et al.* 2004), Common Snipe, which is known to use both wet and dry rice fields (Maeda 2001), and Black-winged Stilt, which occurred in very low densities.

It is not surprising that the amount of water in the paddies is a significant variable determining the distribution of the studied species, which are, after all, mostly waterbirds. Flooding rice fields has been shown to be important for aquatic birds in Central Valley, California, where a higher abundance and diversity of aquatic birds is observed in flooded fields (Elphick & Oring 1998, 2003). In our study areas, Little Egret, Grey Heron and White Stork probably hunt the introduced Louisiana crayfish *Procambarus clarki* in flooded fields (Correia 2001). Flamingos and Pied Avocets filter small invertebrates from the water or the upper layers of sediment (Moreira 1995b) and thus require at least some water to forage, and Black-tailed Godwits forage on rice seeds, which are mostly available in flooded fields (Lourenço & Piersma 2008). Northern Lapwings can use a wide range of habitats, including wetlands and dry cereal crops (Atkinson *et al.* 2002), but in the present case show higher densities in flooded fields.

Ploughing can have a negative impact on birds (Maeda 2001), perhaps due to a reduction in seed availability (Shimada 1999). In California, small waders were more common in ploughed fields, but overall bird densities were lower (Elphick & Oring 1998, 2003). Our results suggest that waders prefer ploughed fields, perhaps because ploughed fields become levelled and are thus more similar to the mudflats where these species also forage. In the case of Black-tailed Godwits, which forage mostly on waste rice in Portuguese rice fields, the preference seems to be explained by higher rice grain abundance in ploughed fields (Lourenço & Piersma 2008). The greater abundance of storks, herons and egrets in standing stubble fields is probably due to higher biomass of their invertebrate prey compared to what is left after ploughing or burning of the stubble (Marques & Vicente 1999).

The high abundance of Northern Lapwings in set-aside fields accords with what is known of these birds' foraging habitat selection in drier habitats. Set-aside rice fields are also important for egrets and waders in Japan (Fujioka *et al.* 2001), where the birds prefer these fields when they are flooded, as we found in this study for White Stork, Northern Lapwing and Common Redshank.

Implications for conservation

The data presented here suggest that rice field management can be of paramount importance for the conservation of waterbirds. Densities are affected by the amount of water in the fields and by straw management. Due to drainage and other human developments, rice fields became a last resort for many species of aquatic birds. Management decisions will thus be of great importance for the conservation of these birds.

Keeping part of the rice fields flooded throughout the winter seems to be an advantageous measure for the bird community. This would also benefit farmers, as the activity of foraging birds in flooded rice fields increases straw decomposition, while reducing weed biomass (Bird *et al.* 2000, Manley *et al.* 2005).

As different species have different preferences, the ideal situation seems to be a mosaic of ploughed, standing stubble and set-aside fields. Ploughed fields seem to be the preferred situation for most waders, whereas storks, herons and egrets mostly use standing stubble fields. Ideally, ploughing should be spread across the winter to have standing stubble fields available throughout the season. The presence of set-aside fields can be advantageous for Northern Lapwing, Common Redshank and White Stork.

Although management of individual rice fields depends on their owners, most rice fields in the lower basins of the Tejo and Sado rivers are part of farming cooperatives. Additionally, rice production in these areas is strongly subsidized by the European Union (EU) (GPPAA 2006). The current situation therefore seems favourable for the application of management guidelines that can guarantee the conservation of aquatic birds, while ensuring the economic viability of rice farming. However, changes in the EU Common Agricultural Policy, namely an increase in alternative crops like maize, could reduce the availability of rice-field habitats. Local and EU authorities must take action among the farming cooperatives to implement environmentally friendly farming in rice fields by guaranteeing the presence of flooded fields in the winter, the ploughing of the fields in the correct periods and ensuring the maintenance of rice plantations. Because rice farming is already subsidized by the EU, these subsidies could be used as warranty for farmers to commit to official management guidelines that ensure environmentally friendly practices through cross-compliance.

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